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Distribution of extinction and star formation in NGC 1569

M. Relaño, U. Lisenfeld, E. Battaner

Dpto. Física Teórica y del Cosmos, Universidad de Granada, Avda. Fuentenueva s/n, 18071, Spain

J.M. Vilchez

Instituto de Astrofísica de Andalucía, CSIC, Apartado 3004, 18080, Granada, Spain

P. Pérez-González

Steward Observatory, University of Arizona, 933 North Cherry Avenue, Tucson, AZ 85721

Abstract. We investigate the distribution of the intrinsic extinction in NGC 1569 using an extinction map derived from the Hα/Hβ emission line ratio. We compare the extinction distribution to that of the dust emission traced by SPITZER IRAC(8 μm) and MIPS (24 μm) maps. The intrinsic extinction shows spatial variations, from zones with negligible extinction to zones with values up to A_V=0.8 mag. We find an extinction shell and establish a relation between this shell and the interstellar expanding structure produced by the stellar winds comig from the Super Star Cluster (SSCs) A and B in the center of the galaxy. We suggest that the extinction shell has been produced by the accumulation of dust at the border of the shell. Although we find a good spatial correlation between the Balmer extinction and infrared emission, there is a spatial displacement between the 8 μm and 24 μm maxima and the maximum in Balmer extinction which needs further investigation.

1. Introduction

NGC 1569 is a dwarf starburst galaxy which hosts two Super Star Clusters (SSCs) A and B at its center. The lack of ionized gas around the SSCs has been ascribed by several authors to strong stellar winds and supernova explosions produced by these clusters. Using long-slit echelle Hα spectra, Martin (1998) identified an expanding shell of ionized gas centered at the position of these SSCs. The distance of the galaxy (2.2 Mpc; Israel 1988) allows adequate spatial resolution and makes it an ideal object to study the distribution of the interstellar dust and gas under the action of the strong stellar winds and supernova produced by the central SSCs.

A common way of estimating the extinction caused by the interstellar dust is the study of the differences between the observed Balmer decrement and the theoretical expected value. Detailed observations of dust emission have been difficult so far but new observations from SPITZER are presently producing

improvements which will be complemented with the missions HERSCHEL and PLANCK.

NCG 1569 is significantly contaminated by foreground Galactic extinction due to its low Galactic latitude. Based on previous studies of the Galactic contribution to the extinction of NGC 1569 (see Israel 1988; Origlia et al. 2001; Devost et al. 1997 and Burstein & Heiles 1984) we assume here a value of the Galactic extinction of $A_V = 1.64$ mag. ($A_{H\alpha} = 1.28$).

2. Extinction map

The Hα extinction ($A_{H\alpha}$) map was calculated using Hα and Hβ images obtained with the WFPC2 on the Hubble Space Telescope and following the method explained in Caplan & Deharveng (1986). In order to study the distribution of the extinction at the global scale of the galaxy and its relation to the star formation and the kinematic features of Martin (1998), we have smoothed the original images to a lower resolution of 6" ($\sim$65pc in NGC 1569).

An extinction map of the galaxy was obtained in two different regimes characterized by different physical conditions: extinction within the HII regions and extinction of the diffuse ionized gas (DIG). For a detailed explanation of the procedure see Relaño et al. (2006). In Fig. 1 we show the combined extinction map. The absolute extinction shows considerable variation over the disk of the galaxy. Once the Galactic extinction is subtracted, we find values up to $A_{H\alpha} = 0.6$ mag, corresponding to an extinction in the V-Band of $A_V = 0.8$. This result agrees with values previosly obtained by Kobulnicky & Skillman (1997).

2.1. Origin of the extinction distribution

The most prominent structure visible in Fig. 1 is the arc formed by the highest values of extinction (values between 1.5 mag and 1.9 mag), which resembles a shell located near the position of the HII region 2 of Waller (1991). This *shell structure* is centered around the position of the Star Cluster A, with an average radius of 90 pc, and correlates spatially with the supershell NGC 1569-C catalogued by Martin (1998). We suggest that the shell extinction structure has been formed by a cumulative deposit of dust at the boundary of the supershell. An estimate of the kinematic age for the supershell is consistent within the age of the Star Cluster A ($\tau \geq$7 Myr, see Hunter et al. 2000) and an analysis of the energies involved shows that the stellar winds coming from SSC A are able to produce the expanding shell and to sweep a significant amount of dust mass contained in it (Relaño et al. 2006).

3. Balmer extinction and distribution of the interstellar gas and dust

The comparison of the extinction map with the Hα emission done by Relaño et al. (2006) shows that the maximum in extinction within the shell structure does not coincide spatially with the maximum in Hα emission, which corresponds to the position of the HII region 2 (see Fig. 1). The Hα maximum is closer to the position of SSC A than the maximum in extinction, which is displaced by $\sim$6" to

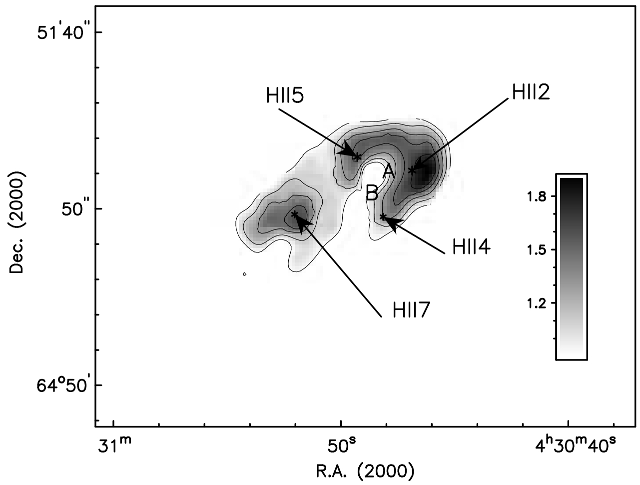

Figure 1. Extinction map (6″) for the galaxy NGC 1569 obtained as a composition of the extinction for the diffuse gas and the HII regions. The extinction shown is the sum of intrinsic and Galactic extinction. The extinction contours are at $A_{H\alpha}$ =0.9, 1.1, 1.3, 1.5, 1.7 magnitudes and the bar shows the adopted grayscale. The extinction values could be overestimated up to a maximum of 0.05 mag due to the underlying stellar absorption (see Relaño et al 2006).

the west. We interpret the displacement as a consequence of dust accumulating in the outer region of the ionized expanding shell found by Martin (1998); the accumulated dust surrounds HII region 2, where ionized gas and dust could be partially mixed within it.

In order to further study the distribution of the dust within the ionized gas, we compared the Balmer extinction and the Hα emission at 2" and 6" resolution with the dust emission at 8μm and 24μm obtained with the IRAC and MIPS instruments on SPITZER (see Fig. 2). We note the following: **i.** While the peak at 8μm coincides with the maxima in Hα, there is a displacement between this peak and the extinction maximum (see Figs. 2a and 2b). A good spatial agreement between Hα, 24μm and 8μm has also been found by Calzetti et al. (2005). **ii.** A displacement is also seen at 24μm, where the maximum is offset from the extinction maximum and closer to the Hα peak. There might be a slight displacement between the 24μm and Hα maxima (see Fig. 2c) but the low resolution of the 24μm image does not allow us to make a firm statement about this. **iii.** Many details of the 8μm emission have a perfect correspondence in the extinction map (see Fig. 2b); e.g. local maxima at HII regions 5 and 7 and tails 1 and 2 (marked by arrows in Fig. 2b). The latter tail (which does not appear in the 24μm image although it is clearly seen in the 8μm image smoothed at the 24μm resolution not shown here) coincides with an HI ridge within the galaxy (see Fig. 11 in Relaño et al. 2006). **iv.** Tail 3 in Fig. 2b, located at the north, coincides with the western ridge and maximum in HI (Fig. 11 in Relaño et al. 2006), but it does not show up in the extinction map. This is most likely due to

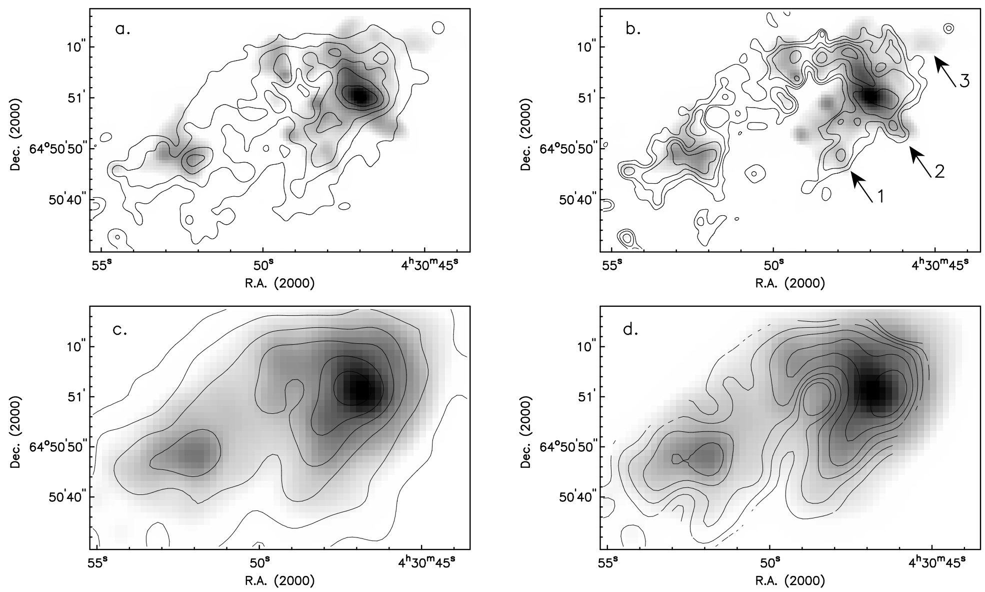

Figure 2. **a.** 8μm (IRAC) intensity map (1.2") with Hα (2") intensity overlaid, **b.** the same as a. but with extinction contours overlaid (2"). **c.** 24μm (MIPS) intensity map (2.6") with Hα (6") intensity overlaid, **d.** the same as c. but with extinction contours overlaid (6").

the predominance of cold neutral gas, as compared to ionized gas, so that the Balmer decrement becomes a poor tracer for the dust.

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